THE

Indian Tea Association

SCIENTIFIC DEPARTMENT

QUARTERLY JOURNAL

PART II

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CONTENTS.

	Page.
Plucking for Quality	53
The Third Imperial Entomological Conference ...	75
The Tulsipara Experimental Block	94
Meteorological Observations in North East India, 1930.	104

PLUCKING FOR QUALITY.

BY

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Very little exact experimental evidence exists on the subject of the influence of style of plucking upon quality.

Some conclusions are based with fair certainty on ascertained variation in tannin and in total soluble solids in leaf of various kinds; but in the main the opinions regarding quality given in the following notes are based upon observation of methods in common practice.

In common practice so many factors are varying at the same time that the effect of any one factor cannot be observed with certainty. Evidence obtained from such observation therefore cannot be accepted as completely reliable, and opinions based upon it must be subject to revision. Such evidence however is the best at present obtainable, and it is hoped that the statements of opinion may be helpful to planters in doubt on some point.

Statements made regarding the effect of plucking upon crop are based on actual measurement and may be accepted as of fairly general application.

There is a very general feeling that methods of increasing crop are of little account just now, and that only production of quality counts. It is very easy to produce good tea: for example, only one leaf and a bud might be plucked and practically nothing but broken orange pekoe or orange pekoe manufactured; but the cost of production would be prohibitive. If the much more moderate recommendations made here regarding strict plucking are followed, it will be found on most gardens that every care must be taken that no loss of crop occurs from other causes. Any increase in fineness of plucking must cause less crop to be taken.

It takes from three to four weeks from the time of last plucking to produce a shoot of two leaves and a bud. After one more week a shoot carrying three leaves and a bud, and weighing twice as much is produced.

Hence from taking three leaves and a bud at least $2 \times \frac{4}{5}$ times, or $1\frac{3}{5}$ times as much crop would be expected as from taking two leaves and a bud only.

In experiment at Tocklai about this increase was found up to the end of June. After that new shoots were so slow to come away from the stouter stalks left, that by the end of the season the coarse plucking (which regarded only shoots of three and a bud as "ready") gained 20% only over the fine plucking.

A very rough estimate of the loss of crop likely to result from strict plucking may be obtained by counting shoots of two-and-a-bud and three-and-a-bud respectively in a sample from the leaf house. For example on a garden in Sylhet fairly finely plucked at about 8 days interval, they were found to be in about equal quantity. This garden might expect a loss of about 10% in crop by adopting a system of strict plucking. If plucking can be only at long intervals greater losses must be expected.

Hence production is always kept in mind.

Unpruned tea. The first flush from unpruned tea gives a good crop and its quality is excellent, quite the best that will be got from it that season. In a wet spring unpruned tea may give not only its best tea, but its biggest flushes in March. If March is very dry, there will be big flushes in April when rain comes.

The benefit of the first flush from unpruned tea is very commonly largely missed by failure to pluck at sufficiently close intervals. On unpruned tea very close plucking must be started from the beginning. It will fall off in yield, and give small hard shoots, with a lot of banjhi, quite soon enough; when poor stalky tea will be made, and will use up a lot of labour per lb. of tea in the plucking. The harder and more frequent the plucking,

the longer will be the time during which the better and larger crops will be maintained.

In the Dooars and in the Surma Valley unpruned tea is very popular, and is believed to yield better than pruned tea. Trials at Tocklai over a series of years, have not confirmed this belief.

In the writer's opinion more and better tea is made from an annually pruned garden over a series of years, if the pruned tea can be plucked fully throughout the season. The apparent benefit from unpruned mature tea is only by comparison with late-pruned tea, not regularly cleaned out, and not fully plucked. Young tea, and tea recently cut back, do yield better if left unpruned.

The great advantage from unpruned tea is that it yields early when there is plenty of labour to pluck it.

Tea which would have given 10 mds. if pruned and fully plucked throughout the season, can, if unpruned, give 3 mds. of good tea by about the end of May, by which time tea pruned in December has given about ½ md., and later-pruned tea much less.

Where labour is short a certain proportion of unpruned, or skiffed tea is a great advantage. It provides remunerative work for labour in what is often otherwise a slack time; and it can be abandoned if labour shortage becomes acute, say, in mid-July, by which time it will have yielded over four maunds of tea per acre, of at least very fair quality, up to this time, without much cultivation. If pruned tea is abandoned in July or even in August, it will have given a very small crop for a large expenditure.

Skiffing may be performed with varying degrees of severity. If so light as merely to level off bushes, they should be plucked as unpruned tea.

If the skiffing is into red wood, plucking should be over one or two leaves according to the amount of wood removed by prun-

ing. Such relatively heavy skiffing gives a somewhat later crop than unpruned tea but still much earlier than tea ordinarily pruned close to the pruning cuts of the previous year. The chief advantages of the skiffed tea over unpruned are that better and more easily plucked leaf is obtainable later in the season, and that there is less risk of losing good second flush teas.

Pruned Tea.

The first Flush. The initial length of growth left, when plucking for the first time after pruning, influences both crop and quality throughout the following season. The shorter the growth left (down to 4″) the better for crop and quality. The first decision to be made therefore, is how closely one may pluck each section without undue risk of deterioration of the bushes.

As a general average 6″ appears to work very well. It should be more on young tea or tea recently cut back, and may be less on very healthy high tea carrying plenty of leaf below the plucking surface. On Hybrid or China tea, (which unless fully plucked tends to flower too freely) it is common to leave one inch less than would be left on indigenous varieties.

Side branches will not naturally flush as strongly as those in the centre. This difficulty is met in one of two ways.

The first is to pluck the sides harder than the centre, thus plucking the bush over a round surface.

The second is to pluck all shoots at the same level, thus losing some crop for a few years, but eventually obtaining bushes on which the sides have gradually been strengthened by the relatively sparing plucking, till they yield almost as well as the centres, so long as the bush is sufficiently well fed to support strong sides.

The second method is generally preferred. It gives a wider bush affording better cover to save cultivation by smothering weeds. After a very few years this wider bush gives the better

crop. The flat surface produced facilitates rapid and accurate plucking. Most important of all, the bush yields shoots more even in size, a great consideration when production of quality tea is in view.

The strong and rapid growth of the first flush yields sappy shoots of large size. On good healthy tea, the normal second leaf may be about 4 inches long. Such shoots make very poor tea, particularly since many of them will have gone banjhi for a time and be plucked when carrying a leaf and a bud of new growth, while the second leaf is a very large hard old banjhi.

The tippings of the first flush form a very small proportion of the season's crop, but it is as well to make the best of it. It is therefore advised that first-flush shoots should be plucked as soon as they appear above the plucking surface, taking either two leaves and a bud if young and soft, or one leaf and a bud only. The taking of one and a bud also helps to establish early the flat plucking surface, which renders accurate and rapid plucking relatively so easy when the rush period arrives. The taking of one and a bud constitutes harder plucking than waiting till shoots of two and a bud are ready. If bushes are considered weak, then 7″ initial growth should be left when one and a bud is taken, instead 6″ when two and a bud are taken.

During the tipping, when very little crop is being made, great care should be taken to get the desirable flat surface to the bushes as accurately as possible : it saves so much trouble later on.

On some gardens bushes are allowed to run on the first flush and then broken back to the level by the pluckers, or skiffed with a knife. The first flush so missed is no great loss; but the second flush will be slower to come away from the thick shoots so left, while it is probable also that the quality of the second flush is somewhat reduced.

The second flush and flavour. True flavour is a quality at present almost entirely beyond control.

It appears to be at least generally true in North East India, that it appears only in the autumn, and at the time of the second flush (late May, and June) when the curious stunting of growth occurs, which has been popularly associated with green fly attack. Flavour may appear also on first flush from unpruned tea similarly attacked. This stunting of growth varies in intensity seasonally, and in seasons of notable intensity does not attack all gardens equally even in the same district. A garden may have it in more marked degree than its neighbours one year, and in less degree in the next. Certain gardens are reputed always to get it, and to keep it late. At Borbhetta it was little in evidence in 1929 and 1930 : in 1927 and 1928 it was so bad as to reduce crop to a very small proportion in May and June and even extended into July. In 1931 it appears to be about to show up strongly.

Its cause is unknown.

When it appears, it may attack unmanured tea, and tea heavily or lightly manured with any combination of fertilizers. Cultivation does not appear to affect it.

It is seldom present in very marked degree (in the plains) on unpruned tea, or on tea which has not been cleaned out. Indeed it appears to be the more marked, the more heavily the bushes have been cleaned out. It generally does most damage two and three years after cutting back, but not generally in the season immediately after cutting back.

Perhaps its association with cleaning out, may account for the belief, common in Assam, that cleaning out produces quality. Through the greater part of the season the more rapid growth of the smaller number of shoots left after cleaning out, would be expected to reduce quality : though cleaning out has a big influence for good in reducing the number of the dangerous banjhi shoots.

The system of plucking certainly does not affect flavour.

The Bazalony plots at Borbhetta, where the experiments on plucking are carried on, always grow the stunted shoots at

the time of the second flush, often to a very serious extent from the point of view of crop. All the styles of plucking being tried get about equally affected.

Not only does the amount of growth left make no difference to flavour; but distinctly coarsely plucked leaf still makes tea of high value when flavour is present; but, of course, the long shoots carrying big coarse third leaves do not appear at such times. When the stunted growth associated with flavour is being plucked, it is certainly not wise to insist on strict two-and-a-bud plucking. Any shoots carrying three small soft leaves and a bud should be taken, rather than break back and throw away the third leaf. As all bushes are not equally affected, care should be taken not to accept old hard third leaves from normally growing shoots; and as soon as normal growth begins to become at all general, strict plucking should be resumed.

When the second flush is coming through it must be decided whether it is to be plucked to the janam, or a leaf left above the point of first plucking. Undoubtedly the second method is better for the health of the bush. Where labour is abundant enough to carry on strict plucking to the janam throughout the season, there is danger of forcing too much out of the bush by the close plucking, particularly if the soil is becoming exhausted. Under such conditions plucking over 6″ to the *janam* has caused tea to deteriorate after a number of years.

At Borbhetta moderately manured tea is still yielding well in its fifth year of strict plucking over six (or even four) inches and then to the *janam*. The pruning wood left is not thick, but good flushes come from it.

The opinion has already been expressed that, on most gardens, pruned tea is not fully plucked. Insufficient labour allows leaves to be left, in the rush season, when none are intended to be left. On an overplucked garden one always finds the weaker bushes plucked below 6″ or other measure fixed. They have gone banjhi and not reached the measure before the measuring sticks were abandoned; and coolies soon take all leaf

showing, however close to the pruning wood. If this fault is avoided there is in general, little danger of overplucking throughout the season, and it is sound to start the plucking down to the *janam*. Not only will plucking to the *janam* give the better crop, but the better quality also, and it better produces that flat surface which makes rapid and accurate plucking relatively easy.

Where a leaf is left it reduces the crop in June quite significantly, at a time when good tea is being made, and there is plenty of labour to pluck it.

Compared to tea plucked at 6″ to the *janam* as giving 100%, plucking to leave a leaf over 6″ gave the following at Borbhetta for second flush teas :—

1927	...	84 %
1928	...	65 %
1929	...	87 %
1930	...	85 %

In 1928 the green fly was extremely bad and growth was slow.

There is a further loss also for the remainder of the season, if both are fully plucked.

Rains Teas.

When bushes are growing normally and healthily, production of true flavour does not appear to be possible; but teas highly valued for colour, strength, thickness, pungency, and "quality" can be made.

Of course, soil and more particularly climate must influence quality, but it is believed that any garden in North East India can produce really good teas from really fine leaf, so long as factory accommodation is adequate, and used to the best advantage.

The rapid growth from very rich, or from heavily manured, soils introduces special difficulties; but it is believed that these can be overcome if only labour is sufficiently abundant, and well trained, to pluck accurately and at sufficiently short intervals.

We are aware that many gardens have been disappointed with the prices obtained after an improvement in the standard of plucking.

In many cases, no doubt, the improved leaf has been so spoilt in the factory that the tea made showed no improvement over that from the coarser leaf similarly spoilt; but it does appear, even with good manufacture, that a quite significant increase in the percentage of fine leaf, while still admitting coarse leaf, does not make so much difference to quality that buyers recognize it, at any rate within a short time. Still, from results in practice, it seems pretty clear that, given good factory conditions, plucking is the factor of overwhelming importance for quality; but the standard aimed at must be an even one.

The admixture of coarse leaf with fine does not appear only to increase the proportion of coarse grade teas, but to lower the quality of the fine teas also. The juice from all is mixed in the rollers, and the taste of the coarse spoils that of the fine. The main difficulty in making the best of mixed leaf is in the withering. Mixed leaf may be withered to 50% of its original weight in say 20 hours. By that time any shoots of one leaf and a bud in dry weather may be dried up, but banjhi leaf or coarse third leaf hardly withered at all. Juice from these old leaves will be squeezed out in the rollers, and the character of the tea made will be very much affected by this dried juice which readily goes into solution when the tea is infused.

If the standard fixed were one leaf and a bud, very fine tea would be made, but very little of it.

A standard of two leaves and a bud gives a fair crop of very good tea. This standard cannot be quite strictly enforced, even with ideal labour, because some shoots will always be banjhi. From such shoots only one leaf with the banjhi bud should be taken in order to re-start growth. If taken while still soft and young it may be placed in the basket; but even single banjhi leaves if they have been missed till old and hard should be thrown away.

Plucking more often falls below standard by the taking of banjhi shoots, than by taking long shoots of more than two and a bud. On many gardens where the nominal standard is two and a bud, it is common to find a large proportion of shoots carrying two hard banjhi leaves in the leaf houses. The unwithered hard shiny leaves show up better there than they do in the baskets.

The taking of non-banjhi shoots carrying a really soft small third leaf makes much less difference, but once the standard is relaxed (even so far as allowing two leaves and an "open" bud) it becomes very hard to exclude real hard old third leaves.

At times when growth is slowing up (when the shoot is about to go banjhi) even the second leaf may be coarse, and hard, and would be better excluded; but it is necessary to give some simple order to the pluckers, and the standard here set is already sufficiently difficult to attain.

The standard of really strict plucking requires not only that fine leaf alone should be taken, but that the bushes must be completely stripped of all ready leaf above the plucking surface. All shoots of two and a bud must be taken, however small. In a week's time they will be either three leaves and a bud, or more probably two hard banjhis. The small shoots of two leaves and a bud add to quality and appearance. What they will become by the next plucking will spoil quality greatly if taken, reduce crop if left and waste time if broken back; reducing quality to some extent whether left or broken back. Shoots of one and a bud should not be taken if plucking is at sufficiently close intervals (7 days on poor to average tea, 6 days on good tea), but if intervals between pluckings exceed 7 days, everything should be taken or the bush will "run away" out of control.

The difficulty in strict plucking is the amount of labour it requires.

Pruned tea plucked weekly is plucked about 39 times in a year, but yields 75% of its crop in about 17 pluckings during July, August, September and October. During the height of

the rush season, tea giving 10 mds. per acre is averaging about 2 mds. green leaf per plucking per acre. Six good coolies appear to be the minimum requirement to pluck an acre of such tea in a day, as it should be plucked. That is, for strict plucking, at weekly intervals, about 1 cooly per planted acre must be turned out daily for plucking alone.

If leaf is to be taken when just ready, so as to make maximum crop of perfect leaf, the seven-day interval is not quite short enough. At Borbhetta on good tea in the season, there is a fair number of three leaves and a bud after a week's interval. The third leaf has to be broken back, wasting time, while what is taken is coarser than if taken when just ready. A six-day interval would be greatly preferable. This would mean that a section plucked on Saturday is plucked again on Friday, then on Thursday and so on. A section plucked on Monday must be plucked again on Saturday, unless plucking goes on for seven days in the week. This means plucking each section 6 times in 5 weeks, or one and one-fifth times per week.

Six-day plucking then requires a minimum of 1.2 coolies per planted acre for plucking alone.

Tea yielding over 10 mds. per acre would require more than this.

It is noticed at Borbhetta that the labour per acre required for plucking is not very greatly increased as crop increases from about 1½ md. green leaf up to about 2 mds. green leaf per acre. With 6 coolies per acre plucking, the latter figure means about 13 seers * leaf per cooly per day. When flushes exceed 2 mds. green leaf per acre per day, the average brought in per cooly still exceeds 13 seers by very little or nothing, unless strictness of plucking becomes relaxed (as it is apt to do on rush days) or the seven-hour day is extended. Strict plucking at 6 days interval, in practice is known to be attempted only on gardens where the

* Only the regular pluckers average this amount. Men unused to plucking, when forced to pluck only on rush days, bring in about half the amount. The whole labour force, if possible, should be trained to pluck, and kept practised in the art.

total labour available for all purposes (including leave) approximates to two coolies per acre.

The six-day plucking is clearly out of the question for the great majority of gardens.

The figures given for labour requirements, can of course, only be taken as approximations. A great deal depends upon the physical condition, the standard of training and natural skill of the labour force, and upon the customs established on the garden. Many gardens plucking really good leaf use more labour than the minima here mentioned, while others pluck at least very fair leaf with less than a cooly per acre free for plucking; but most gardens find themselves with a labour force inadequate for strict plucking in the rush months.

Everything possible of course will be done so to arrange garden work, that the maximum number of coolies is free for plucking at the critical times. The "Garden Calendar" at the end of these notes, not only summarizes them, but indicates the nature of the arrangements which may be made. The ideas on cultivation and pruning there inferred will be explained in later notes.

It is often possible also to allow a section not growing strongly at the moment to run another day, in order to pluck a day earlier on a section in danger of running away.

With the best of arrangements, labour is often short of the requirements here indicated. What then can be done?

Here it is suggested that a definite decision must be made before the rush comes. One must either maintain the strict standard of plucking, or go definitely for a poorer class of tea.

One must either reduce the area to be plucked, or pluck the whole area at longer intervals.

There is of course more leaf ready in 8 or 9 days than in 7 days, but a lot more of it will be shoots of three leaves and a bud or more. If two leaves and a bud only are still taken, those taken from above older leaves will be of poorer quality than if taken when just ready, so that quality is still reduced.

If the third leaf is left on the bushes, following crops will be still further reduced in quality and in quantity also. If the third leaves are broken back, quality and quantity still suffer to some extent, while a lot of the pluckers' time is wasted.

Very fine tea certainly has been made in Upper Assam by plucking at intervals of as much as ten days; but the plucking was selective, and bushes very thoroughly stripped at each plucking. Not only was coarse leaf excluded as carefully as possible from the baskets, but it was common to throw out unwithered coarse leaf from the withering houses, before taking withered leaf to the rollers. Unwithered hard leaf shows up bright and shiny among the dull withered leaf.

To make first class tea from ten-day leaf demands a very high degree of skill and care from the pluckers and very close supervision; and it must be impossible to maintain the standard even then, during periods of very rapid growth on vigorous tea.

There is certainly much more risk of taking coarse leaf when plucking at long intervals. There is loss of crop from taking immature leaf, and from plucking over stout shoots after breaking back. Time is wasted by breaking back, and by the extra care necessary. It is at least very probable that more first class leaf per cooly would be made by plucking a reduced area at seven days. The ten-day interval may suit some gardens where labour and staff are accustomed to it, particularly where the tea is not very vigorous; but on most gardens in the plains, it is certain that plucking intervals exceeding seven days mean taking coarse leaf in the rains.

It appears better, when plucking at longer intervals, to lower the standard of plucking definitely, and take all shoots both of two leaves and a bud and of three leaves and a bud. If bushes are still stripped at each plucking, particularly of banjhi leaf, the third leaf will be fairly soft and not make bad tea.

Shoots of two or more banjhi leaves should still be very definitely rejected. These will not wither and will spoil the tea, and it is from these that most of the stalk comes.

Naturally intervals will be made as short as possible, but on this lower standard quite good tea can be made when plucking at 10 day intervals. As more leaf per cooly is taken, costs per lb. of tea will be reduced, but teas of the very first class are not to be expected.

The lowest standard of all is to pluck as often as possible (which may mean intervals up to 14 days) and take every shoot which the plucker's fingers can snap, including shoots of four leaves and a bud, and two and three hard banjihis : leaving small shoots on the bush. Naturally it produces poor stalky tea ; but it may pay well on very vigorous bushes, by producing large crops per acre at low cost. From poor to moderate bushes, it produces a crop which on the present market, sells below the cost of production as far as rains teas are concerned. The complete abandonment of systems approximating to this last, would sufficiently reduce the total crop on the market to restore good average prices. On such systems costs per lb. are reduced all round; including factory costs, since such leaf is not worth expensive manufacture. Bad as such systems are for the industry in general, one cannot blame those who practise them while they are able to show good profits. At the present moment they show profits only on the most vigorous tea.

Even in 1930 good teas have sold well, and a fair number of gardens have shown that good teas can be made even in the rains. Most gardens have therefore started 1931 with the intention of making the best teas they can. The majority of these will find in July or August, that they have not enough labour to maintain the strict standard of plucking.

Where the labour shortage is expected to be temporary only, it is common to skiff bushes lightly, instead of allowing them to grow unchecked so long that it is impossible to bring them back into plucking when labour is again more plentiful. The skiffing aims at reducing the level of the bush roughly to what it would have been if it had been kept plucked.

From enquiries made it appears that this skiffing can be performed with little more than half the labour which would be

required for plucking the same area; while frequently a class of labour can be found for this work which cannot or will not pluck.

From information collected from a number of gardens it appears that it may be taken as a very rough rule, that the interval between skiffing and the next plucking is about equal to the interval between the skiffing and the previous plucking. That is, if a section is unplucked for 14 days and then skiffed, it is pluckable again after a further 14 days. Three weeks' pluckings have been lost, but the section is still in condition to yield good tea for the rest of the season, which it would not have been had it run for three weeks unchecked.

For the skiffing, sometimes long laths of bamboo, and sometimes big sharp knives are used. The former make it more certain that only green easily broken shoots will be removed; the knives make a cleaner job; but there is some danger of cutting into older stems, in which case pluckable shoots will be slower to appear. Knives properly used are preferable Bushes skiffed by knives carry many cut and bruised leaves, but the surface of a bush after an attack by bamboos looks as if a light hailstorm had passed over it, when the bruised and broken leaves and shoots have turned brown.

If left too long unplucked, *e.g.* for a month, very long hard shoots will have grown. If skiffed to remove only about 14 days growth, plucking may recommence after not much more than another fortnight, but the leafy bush left will shut up early: if cut by knives into hard twigs to remove a month's growth, plucking will not recommence for another month at least, and the tea made will approximate to first flush tea.

If a section last plucked on, say, July 15th., is skiffed at the end of July, and again in mid-August, it may be plucked again in early September, by which time labour may be available to keep it in plucking for the rest of the season; but about 25% of a full season's crop has been lost with little saving in expenditure and no compensating benefit: while the tea has been very

hardly treated. If as much had been spent on plucking as on skiffing, at least half the area could have been fully plucked, while the remainder left unplucked would improve greatly, and could be pruned early for good and early crop next season.

Light skiffing in the rains is a useful expendient for meeting a labour shortage of short duration, but it should not be pushed to extremes.

Labour shortage in the rains must generally be met by leaving areas out of plucking. If any considerable proportion of a garden has so to be left annually, the possibility of over-plucking it need not be considered. Areas left will be improved, and should be chosen from cut-back, or weak sections. If healthy, mature sections have to be left, they should as far as possible be chosen in the previous November, and left unpruned or skiffed to give a good crop early.

October and November teas. The crop for October is commonly as big as that for any rains month, but temperatures are falling, and humidity decreasing. The rate of growth is falling off. The big crop is coming from the large number of plucking shoots on the well filled bushes. At this time while a strict standard of plucking should be maintained it is often possible to lengthen intervals between pluckings and still keep bushes within control. If this is necessary on account of labour shortage, it is preferable to do it, in order to keep as large an area as possible for production of valuable autumnal teas, rather than leave further areas out of plucking.

As November approaches, and certainly in November, not only may intervals between pluckings be increased without harm, but it is possible that they may be so increased with advantage, since it is suspected that autumnal flavour is only fully developed in shoots which have been some time on the bush.

Again, as in June, when flavour is present the standard of plucking should allow the taking of shoots of three leaves and a bud.

GARDEN CALENDAR.

November. Plucking is still very important but pressure is greatly relaxed. Intervals between plucking may generally be increased.

It is strongly suspected indeed that autumnal flavour of this time of year only shows strongly on tea from shoots which have been some time on the bush; so that it may be even desirable to increase plucking intervals in November.

At times when flavour is good, tea made from leaf with a fair proportion of three leaves and a bud still sells very well.

Cutting back should be finished off.

Light pruning may start on some areas such as young tea, or tea which has been unpruned, or unplucked for whole or part of season.

Cleaning up of garden by light hoeing should be pushed on; or, if sufficient labour is available, a one-chop deep hoe, (scraping off jungle and burying it together with prunings) started on areas which have been pruned. Deep hoeing may be started on other areas of gardens, where labour is so abundant that the whole garden can still be clean by the end of January, or soon after.

When labour is available, November is a good month for infilling or planting tea, at least in Assam.

December. Plucking finished.

Most important work is rapid pruning by cutting across as much of the garden as possible, leaving correct length of wood, but without cleaning out.

Earliness of pruning makes an enormous difference to crop, and costs little.

Light hoe, (or one-chop burial hoe following pruning) by men not suitable for pruning.

Forking to remove jungle around collars, and to destroy caterpillar chrysalids by any children and women unable to prune.

January. "Cut-across pruning" finished off. Cleaning out of areas previously cut across pushed on as rapidly as convenient. The finishing of the cutting across is the most urgent work.

Cleaning up of garden by light hoe, or one-chop burial hoe, finished if possible. Deep hoeing of part of the garden is advised if the whole garden can be clear of jungle by the end of January or soon after.

Forking by children and women continued.

February. The cleaning-out of areas previously cut across should be finished off by about the end of the month.

It is hoped that by this time, the garden is clean of jungle left from last rains. If so, sections hoed in October and November, or even December may require light hoeing to remove weeds. Even if land is clean, but has consolidated, it is of some benefit at this time to light hoe with the object of leaving a mulch of fine soil over the surface as a precaution against drought.

If the soil is very dry, deep hoeing is better avoided, but if still moist a one-chop deep hoe may do good on areas which have not been deep hoed for, say, 3 years or more.

Forking around bushes continued.

Manuring should start, particularly if applying manures not readily available, *e.g.* oilcake, animal meal, cyanamide, cattle manure.

March. Every effort should be made to finish off rapidly any pruning still to be done. Rather than carry on pruning too late, part of the garden should be left cut-across without cleaning out. Such areas will look yellow, ragged and untidy in the spring, and probably will get red spider; but will suffer very little loss in crop, if cleaned out in previous years. Cleaning out however should not be neglected for more than two years in succession, even if it means continuing cleaning out till the end of March.

Manuring should be finished off by the end of March. All sections manured should be light hoed immediately afterwards. Light hoeing on clean soil merely to cover manures may be done at an increased task.

Light hoeing should continue on all other sections which carry weeds; and even on clean sections which are clean but badly compacted, if droughty conditions are holding.

If soil is clean and still loose on the surface, it is waste of labour to hoe at all.

Deep hoeing in March should be avoided altogether. The cutting and disturbance of roots hinders growth and reduces crop for the following season.

If forking around bushes still remains to be done, it should be confined strictly to removal of jungle, and deep disturbance of roots around the collar avoided carefully.

Drain cleaning should commence.

Plucking of unpruned tea commences. In a wet spring unpruned may give its heaviest flushes of the season in March. In these seasons unpruned tea requires plucking well and at close intervals even in March. The first flush from unpruned tea is of good quality.

Tipping of pruned tea commences. To make things easy for the rush season, strict plucking to a flat surface should be enforced. taking (at this time of year only) even one leaf and a bud above the height fixed.

April & May. Except on gardens with a lot of unpruned tea, these are months of very small crop.

All works referred to under March (except pruning) may continue.

After rain has fallen, jungle growth becomes rapid, and should be suppressed as soon as it grows significantly, to make things easier later on.

Plucking strictly to a flat surface should be enforced. "Green fly" may start badly in May. If so, a very small crop of wonderful flavoury tea will be made. At such times no breaking back should be done, but the whole shoot of small three leaves and a bud be taken when present.

In these months (together with March if little manuring is done) labour can usually best be spared for such works as repairs to buildings, roads, bridges, etc.

April and May in most districts are good months for infilling and new planting of tea, and the spring is the best time for planting shade trees.

Sowing of green crops should start as soon as rain has fallen but should not continue after

mid-May, so that the last ground green crop can be hoed in by the end of June, after six weeks' growth.

Any manuring left over from March should be finished in April.

If labour is likely to be short in June, second doses of manure may be applied in May, leaving it as late as possible.

June. Plucking is in full swing. If plucking surfaces are now clearly established, there will be little trouble in the following rush months. Strictly fine plucking should be insisted on as soon as "green fly" effect disappears.

Every effort should be made to have the garden thoroughly clean in this month, so that as little cultivation as possible may be necessary for the next two months.

All ground green crops should be disposed of, and semi-permanent crops like boga medeloa should be left rigorously lopped by the end of the month.

Where second doses of manure are given, they should be applied in June. Early July would do, but plucking is then generally absorbing all the labour available.

July & August. Everything must be sacrificed to maintaining close and accurate plucking of strictly fine leaf at short intervals.

Cultivation (with the sole object of keeping down jungle) will be maintained only when labour can be spared without reducing efficiency of plucking, or when jungle growth is interfering seriously with plucking.

Where fine tea is to be insisted on at cost of crop, it may be necessary to begin to leave areas out of plucking. Weak areas, cut-back areas and areas which have not been pruned should be the first to be left out.

September. Plucking is still almost the only consideration, but as rice planting has ceased or slackened, more labour is generally available for cultivation where necessary.

October. October commonly gives about as big a crop as any month and its strict plucking must still be the chief consideration on the garden; but the big crop is coming as much from full bushes, as from rapid growth.

It often may be possible, now, to increase intervals between pluckings without letting bushes out of control. If so, it is by this time preferable to do so, (and so keep a larger area in plucking for the valuable autumnal teas), rather than drop further areas out of plucking entirely.

In this month holidays interfere seriously with work; but, apart from holidays, labour attendance is often very good. Where possible a start should be made with cleaning up weedy sections by light hoeing. A start should be made also with any cutting back which has to be done.

Where sufficient labour is available this is an excellent month for infilling vacancies, or planting out tea.

THE THIRD IMPERIAL ENTOMOLOGICAL CONFERENCE.

BY

E. A. ANDREWS.

When on leave in England in 1930 the writer took the opportunity of attending meetings of the above Conference, which was held in London in June. A detailed report of the proceedings at the meetings was submitted to the Sub-Committee with the Annual Report of the Entomological Branch of the Department, and it has been suggested that a general account of the proceedings of the Conference would be of interest to readers of this Journal as the well-chosen list of subjects for discussion not only brought up matters of general interest to agriculturists in general, but also matters of distinct interest to those connected with the tea industry.

The Conference was attended by entomological workers from all parts of the Empire, so that a considerable variety of experience was brought to bear on each subject, and there were frequent differences of opinion, with resulting argument and discussion, which made the meetings extremely valuable.

The first subject brought up for discussion was that of the organisation of entomological departments. Here, as may well be imagined, opinions were largely at variance, and it was plain that any Imperial organisation which may eventually evolve will have to be so devised that while there is unity in general, diversity will be possible in particular. It is a fact at the present time, that in most of the colonies there is little or no "entomological" organisation of entomological work. What has generally happened has been that as each existing department—agricultural, veterinary, medical, and so on—has come up against entomological problems requiring solution, one or more entomologists have been appointed, as officers attached to the particular department. Thus, in one country, one finds several entomologists all working independently of each other, some under the control of an agriculturist, others under the control of

a veterinary surgeon, others under the control of a medical man, and so on. Large corporations, also, in many countries, employ entomologists to investigate their special problems. The existing state of affairs in India is a typical example. Under such circumstances, there must undoubtedly be a certain lack of co-ordination and a certain amount of overlapping and unnecessary duplication of effort, while the individual officer undoubtedly works at a certain disadvantage owing to his isolation. The opener of the discussion suggested that the logical state of affairs would be that each country should have its entomological organisation, under the control of an entomologist, to which the other departments could apply for information and assistance in investigating their problems. Many subsequent speakers, however, were by no means in agreement, and were of opinion that such an organisation, by divorcing the entomologist from the department with which his particular problem was connected, would lead to a decrease in efficiency. It appeared to be quite obvious, as the discussion proceeded, that in some colonies this would be so, and it was apparent that the first, and a supreme, obstacle to be surmounted would be the existent variety, in different colonies, of the existing organisations into which any new organisation would have to dovetail. In fact, towards the end of the discussion Mr. Fryer, of the Ministry of Agriculture and Fisheries, pointed out that in Great Britain itself there are already so many independent organisations that the formation of a central organisation is impossible, and the policy followed is that of assisting existing institutions.

Mr. Gibson, Dominion Entomologist, Canada, gave a detailed account of the organisation of entomological work in that country, where there is a special entomological branch of the Department of Agriculture, with central and branch laboratories, which takes charge of work on most of the entomological problems throughout the Dominion. While it was apparent, from his account, that this entomological branch of the Department of Agriculture of Canada has now attained to considerable dimensions, and covers the major portion of the entomological problems

being investigated in agriculture, forestry, and veterinary entomology, there yet remain many investigators working outside its control, and medical entomology is still left to the medical institutions. In the Irish Free State agricultural entomology appears to be well-organised, but here again medical entomology is divorced from it. In all other colonies entomological work is done by officers attached to different government departments, and by workers attached to different institutions under varying authority, so that there is little or no central control. The Australian delegate gave an account of the difficulties in the way of organisation and even co-operation in the Commonwealth which recent events in other directions have shown to be by no means overdrawn.

Thus, the problem of the organisation of existing workers throughout the Empire into an Imperial Entomological Service, attractive and desirable as that would be from many points of view, is one hardly possible of solution at the present time, and the whole discussion, to the writer's mind, emphasized the importance of the development of the existing Imperial Institute of Entomology (formerly the Imperial Bureau) as a central "clearing house" through which co-operation between the various Colonies, organisations, and workers may be satisfactorily maintained.

At the next meeting the subject put forward for discussion was that of entomological work among backward races, and a feature of this discussion which struck the writer particularly was the remarkable unanimity of opinion with regard to the relative values of different measures, and the best methods of approaching the problem. The only matter, in fact, on which opinion was not unanimous, and experience not identical, was the question of the use of poisonous insecticides, and even here the differences experienced appeared to be of degree, and not of kind, depending on the degree of intelligence and the educational level of the peoples concerned, and on the degree of opportunity for propaganda, instruction, and control afforded by existing circumstances.

Mr. Ritchie, of Tanganyika, in opening the discussion, covered a great deal of the ground. He first pointed out that it must be regarded as an axiom by all workers that the degree of success obtainable is directly proportional to the amount that can be taught to the people concerned. In most cases, conditions in these countries are such that it is impossible to maintain an expert staff adequate for the supervision of all that is being done, and the difficulty of training an indigenous supervisory staff to a level such that reliance may be placed on it is enormous, and often insuperable. Under such circumstances the degree of success to be hoped for from any methods demanding intelligent application is small, and can only be raised very gradually as the education of the cultivator progresses. In consequence, methods by which control is taken entirely out of the hands of the cultivator are of primary importance, and demand prior attention.

The first of these methods was that of breeding resistant strains of plant, which could be issued to the indigenous cultivator, and would automatically effect control without any effort on his part. This, of course, was a question for the plant breeder, and the co-operation of such workers was essential wherever control work was being attempted among backward races.

A second measure was the establishment of machinery whereby it could be ensured that none but clean and uninfested planting material should be distributed to the cultivators. This applied both as regards vegetative material and seed. Here, again, a reduction of infestation in the field would automatically accrue.

A third method was to endeavour to obtain limitation of the growth of crops to suitable growing areas. Certain crops, for instance, suffered badly from insect attack if planted above a certain altitude—here, a matter of interest to planters, the speaker instanced thrips—while others were found to become badly infested on certain types of soil. There were two methods of bringing about such limitation—education and legislation, the

latter generally being necessary in the early stages, but becoming less so as experience provided education.

Another aid to control was the limitation of the area planted to that which could be properly worked—an unpopular, though necessary, measure to enforce which legislation will probably always be necessary. It struck the writer at the time, as it will probably strike the reader, that the speaker here referred to an aspect of the question by no means confined to work among backward races, and to a measure which would afford an immediate solution of many labour problems.

A fifth manner in which control could be exercised was by emphasizing the importance of, and where necessary insisting on, the destruction of residual material between successive crops. The non-observance of this precaution by indigenous Indian cultivators is a matter of common knowledge among planters.

The experience of the speaker had not led him to consider that insecticidal treatments were of much value, in work among backward-races, but he emphasized the importance of education in cultural methods, which it is in the power of every cultivator to employ on his own initiative, once he can be made to understand their advantages.

Subsequent discussion, as mentioned above, consisted largely in confirmation of the observations of the opener. It was the general opinion that education is preferable to legislation, and it was stressed by several speakers that educational propaganda should precede, and continue actively during the introduction and enforcement of, legislation. Various systems of educational work were outlined, ranging from the introduction of simple entomological facts in school reading books to commence the education of the child, to the exhibition of instructional cinema films to extend the education of the adult. Most planters would endorse the experience expressed by all who referred to film propaganda, that only films made under local conditions were of any value, as films showing the use of implements or methods not in common use among the cultivators

themselves were not comprehended. Remarks made with regard to the necessity for a careful study of the psychology, religions and superstitions of the people concerned, so as to avoid offending their susceptibilities, and to ensure the recommendation of methods which should be acceptable, would have been unanimously endorsed at any planters' meeting.

Experience in connection with insecticidal control, as has been stated above, was varied. One worker had found no difficulty in introducing insecticides, it being the profound conviction of the people with whom he had to deal that it were better that someone should die than that the crop should go. Others had succeeded in overcoming initial difficulty, either by educational propaganda, legislation, or both. It was, however, obvious, though the fact received no emphasis, that the poor resources at the command of the cultivator, and the small margin of profit per acre, rather than any inherent objection to insecticides, had in many cases been the chief deterrent.

The next subject brought forward for discussion was the control of insects by cultural methods, which was opened most appropriately by Mr. F. A. Stockdale, C.B.E., Agricultural Adviser to the Secretary of State for the Colonies, who was able to speak with authority from personal experience of the results obtained in areas as widely separated as the West Indies, Tropical Africa, and Ceylon and India. Mr. Stockdale said that in an extended experience in various tropical countries he had come to be greatly impressed by the value of cultural methods of insect control, particularly in connection with permanent crops, and in his opinion this aspect of the problem merited the attention of entomological workers. He then proceeded to cite cases which had come under his notice in different countries, and suggested that work might profitably be carried on on the following lines—

—the breeding of resistant varieties of plant.
—the regulation of planting seasons and systems.
—the improvement of cultural operations.

He was of opinion that it was becoming increasingly evident that the presence of certain pests is due to, and an indication of, our lack of knowledge of plant nutrition, and he believed that more attention should be devoted to the study of plant physiology, and particularly to plant nutrition.

Owing, probably, to the fact that of necessity so much had been said about cultural control in general during the previous discussion (on entomological work among backward races), subsequent speakers largely confined their remarks to specific instances in which they had definite evidence of a connection, whether positive or negative, between some cultural factor and intensity of insect attack. An attempt is here made to classify these instances under the cultural factor involved.

Unsuitability of soil type—certain scale insects attack cocoa on the Gold Coast; this had been found to yield somewhat to better cultivation in the past, but it is now known that the reason for the intense attack is that in the first instance the cocoa is planted on an entirely unsuitable type of soil. A mite which attacks vegetables in S. Africa attacks only those grown on light soils. Insect attack, throughout Mauritius, is serious only where the soil is poor.

Cultivation—thrips has been largely controlled by improved methods of cultivation in districts as widely separated as Ceylon and the West Indies. Attack by certain species of scale insect, in Ceylon, has been ameliorated by improved methods of cultivation. The banana weevil borer, in the West Indies, is definitely least where cultivation is best. The mite, referred to above, which attacks vegetables in S. Africa, can be kept down by deep ploughing, as the nymphs are unable to pass through six inches of soil. In the case of a thrips attacking fruit trees in Canada, intensive cultivation resulted in more intense attack. This latter observation, it may be noted, is in agreement with many more observations on fruit trees, both in connection with thrips, mites, and scale insects. Later in the discussion Mr. Fryer, of the Ministry of Agriculture and Fisheries, cited the

fact that the apple capsid damages only fruit trees under cultivation, and not those in grass, also that greater development of the head of the tree, as compared with the root, was correlated with increased attack. This phenomenon appears to be connected with the increase in vegetative growth produced by intensive cultivation, and is amply illustrated, in tea, by a comparison of insect damage done to the tea-bush in the plucking area as compared with the comparatively small amount done in a seed-bari. It has been shown that in the case of a wire-worm which attacks wheat in Canada tilling to a depth of six inches results in increased attack, while tilling to three inches improves matters. This is due to the fact that the insect can only deposit the egg in loose soil, and not in the caked soil below, and the temperature in the top three inches of soil becomes high enough to kill the egg.

Drainage—"Where moisture conditions are properly "preserved" cacao remains free from thrips in San Thomé, and in general the pest is found to "yield to drainage". Improvement of drainage conditions has brought about great reduction of damage by frog hopper on sugar-cane in Trinidad. Damage by shot-borers in Europe is always worst in conditions of excessive drought or excessive moisture.

Pan—several instances were given of the pronounced influence of pan in producing susceptibility to insect attack. In the Seychelles a pan is apt to form below the decomposition level of the disintegrating coral rock, and coconuts growing in such situations suffer badly from scale. Breaking of this pan, followed by manuring, brings about an improvement. Scale attack on cocoa on the Gold Coast is also associated with pan. In Sierra Leone, wherever coffee bushes were attacked by scale insects, they were always found to have a twisted tap-root and poor root systems, and the subsoil was compacted into a pan. In the case of cotton the same condition prevailed, any plant which found a pocket of good soil showing much less liability to attack.

Manuring—proper manuring has proved most efficacious against shot-hole borer in Ceylon, and attack by scale insects

has been considerably reduced by this means. Froghopper on sugar-cane in the West Indies has been found to be associated with a deficiency in lime, and the application of this substance as a corrective has given good results in cases where drainage alone has not proved sufficient.

Adjustment of cropping season—several references were made to the value of crop rotation in checking the multiplication of pests. In the West Indies cotton was formerly grown in the wet season, giving large, woody plants with a long period of bolling and suffering much damage from pink bollworm and fungi. This has now been declared a close season for planting cotton, which is now planted at the end of the wet season, with the result that in 1929 there was no pink bollworm.

Clearing of residues—In Barbados considerable reduction in damage to sugar-cane by root-borers has been brought about by cultivating the land and splitting the stools at the end of the cropping season, to prevent "carry over" from one season to the next.

An interesting case of cultural control by the indirect method was cited by a delegate from New Zealand, in connection with the maggot fly of sheep. This insect attacks sheep owing to the presence of intestinal worms which cause diarrhœa, and proper dressing of the pastures to deal with the worms results in elimination of attack.

There were several references to the relation existing between plant nutrition and insect attack. In Tanganyika it has been found that the degree of thrips attack depends on the rate of flow of sap in the plant. Froghopper, in the West Indies, varies in its effect on the plant according to sap conditions, and it is found that in one year 50 insects will do more damage to one plant than 500 will do in the next. The apple capsid, in Europe, always accompanies vigorous vegetative growth.

One meeting was devoted to the discussion of the locust problem, a problem the magnitude of which it is very difficult

to grasp, and which was emphasized by the very considerable variety in experience quoted at the meeting. Mr. Uvarov of the Imperial Institute of Entomology, in opening the discussion, said that the most burning question of the moment in connection with locust control was the desert problem, as it was essential to ascertain the factors responsible for the production of swarms. He remarked that the first concentration, before migrating, to be observed and recorded was in 1925, on the Red Sea coast. In other words, the first observation of any value with regard to the origin of locust swarms was made in 1925. Those who have read the tenth chapter of the Book of Exodus will be aware of the fact that a swarm of locusts visited Egypt in the year 1491 B.C., and that that swarm came from the east. It is estimated that the cultivation of crops commenced somewhat between 15000 and 12000 B.C., so that there is every reason to suppose that that was by no means the first swarm to give trouble, but there is considerable food for reflection in the thought that it has taken mankind at least 3,416 years to locate one spot in which locusts assemble for migration into Egypt. Since 1925 concentration of locusts has been noticed in the Sahara desert and in Sind. There are, of course, many species of locust, but the locust of the Bible, *Schistocerca gregaria*, is the most widespread of all, ranging, in its migration, from Morocco and Algeria in the west to Assam in the east (the writer picked up the wing of a straggler from a swarm in his bungalow compound at Tocklai in December last, and the swarm itself was observed over Dergaon in the Golaghat district). To the north the insect ranges as far as the Trans-Caspian area, and south as far as Tanganyika and French Equatorial Africa. The breeding grounds of the locust are as yet unknown. Arabia has been located as one, but the precise area is not yet definitely ascertained. Ballard has lately definitely ascertained that locusts migrate from Arabia to Egypt, and it is supposed that they migrate from that area to India *via* Baluchistan. It is thought by some that the locusts visiting North-west Africa breed in the central Sahara; others suspect the region of Lake Chad; still

others suspect French Equatorial Africa. An obstacle in the way of investigating this matter has been the inaccessibility of the areas concerned. On the other hand, one observer of repute remarked during the discussion that he inclined to the belief that there were no permanent breeding grounds, but that locusts breed, in the solitary phase, anywhere where moisture conditions happen to be favourable. He was of opinion that they breed near the seacoast in winter, and go inland to other breeding places in the summer, where they swarm. Another delegate had observed, in Kenya, that it was the habit of the locust to go into the hills, for a week or two—he thought, to swarm—and then go down to warm country and begin to lay eggs.

We regard to the actual migration similar differences in behaviour were recorded. The opener of the discussion gave it as his considered opinion that it was now almost definitely proved that the insects migrate in the same direction for several generations as far as the climatic limit for breeding. A delegate from the Sudan, however, said that this was certainly not the case there, as swarms came in regularly from the north and east, and then went back again, while swarms had been observed to fly over from Kenya and go back without settling. Another delegate, from British East Africa, was of opinion that the course taken by successive swarms in migration was of a spiral form, and swarms had been observed to fly from Kenya to Tanganyika and in some cases return and in other cases not.

Recent observations have brought to light the fact that one species of locust can appear in two distinct phases, which can change one into the other. In one phase the insect leads a solitary existence. In the other phase it collects in swarms and migrates. The two forms may vary considerably in appearance, and it is now known that various species of locust are indigenous, in the solitary phase, in regions where swarms are not experienced, as well as in regions where swarms occur. The factors controlling the transition from the solitary to the migratory phase are as yet mainly a matter of conjecture, and varied opinions were expressed by delegates from different colonies. One

delegate, however, stated that he had been able to produce the migratory phase from the solitary phase by overcrowding in cages.

The discussion mainly centred round this question of the origin of swarms, and this was to be expected, as at present the only method of dealing with the insect is to carry out extensive, and highly organised, campaigns over wide areas to deal with the swarms as they come along. Mechanical and chemical methods have now been worked out which can be effectively used, but the numbers in which the insects occur, and the wide areas which they suddenly invade simultaneously, render the success obtained in these campaigns more or less proportional to the scale on which they can be organised and carried out. Thus successful control entails the maintenance of more or less permanent, extensive and well-equipped, organisations, resulting in a permanent, and very considerable, charge on the countries concerned. Ability to concentrate on the insects, in comparatively restricted areas, at or before the time of swarming, would alter the whole aspect of the locust problem, and increase the efficiency with which control could be exerted, at an enormous saving of labour, material, and money.

The magnitude of the locust problem was referred to above, and it has now been realised that progress in its solution is well-nigh impossible unless investigations are carried out simultaneously over large and widely-scattered areas. Such a situation demands some means of co-ordination, and a central Locust Control Board has now been formed, and an Empire Scheme of Locust Research inaugurated, by which it is hoped to regulate and accelerate progress in the work.

The next subject brought forward for discussion was that of the biological control of insects, and centred mainly round the question of control of insect pests by the use of insect parasites and predators. This branch of economic entomology is one of comparatively recent origin, and up-to-date much of the work in this branch has been carried out by North American workers,

though the work done has been by no means confined to America. One principal reason for this is the fact that America has organised an entomological service of sufficient extent to permit of officers being detached for work on this highly specialised branch of the subject while at the same time retaining a sufficient staff to deal with more general problems.

Another important reason, however, has undoubtedly been the fact that North America being a comparatively young country, introduction of plants from old-world countries has played a large part in the development of agriculture, and pests, indigenous in the Old World, but originally absent from the New World, have been introduced, without the parasites which prey upon them in the Old World being introduced too. It is in such instances that biological control might be expected to be of most value, for in most cases, where both pest and parasite are indigenous, a balance between the two had been struck long before economic entomology had been developed as a science. It is, in fact, a matter of experience, first, that in most cases such success as has been attained has occurred when an insect, not indigenous to that country, has been introduced and become a pest; second, that biological control is most successful under island conditions, or, in continental areas, where both pest and parasite have been restricted, by either climatic or topographical conditions, to well-defined localities. In the case of indigenous pests, and under typical continental conditions, factors enter into the problem which are absent in the former cases, and which afford difficulties, and impose limitations, sufficient to cause some workers to consider it doubtful whether biological methods of control can ever be capable of general application.

The general realisation of this important aspect of the matter was reflected in the discussion, and as delegates from the Old World and from continental areas outnumbered those from the New World, and from island areas, scepticism was somewhat more marked than enthusiasm. One point that was emphasized again and again was the fact that in all cases other control factors have operated side by side with the biological factor, and

that due allowance must be made for the results of their operation.

There is no doubt, however, that in certain cases the introduction of a parasite has been followed by a marked reduction in the numbers of a pest, even where complete control is not claimed, and as experiment continues and experience accumulates more and more of these instances come to light. In certain island areas, notably Hawaii and Fiji, biological control appears, up to the present, to have been entirely successful. In Mauritius and New Zealand some success has been attained. In continental regions successes have been obtained in certain areas, where conditions have been exceptionally favourable for the development of the parasite, and the limitation of the spread of both pest and parasite—places which, in fact, are ecologically islands. In other areas, however, failure has, at present, to be admitted.

It became apparent, during the discussion, that the general feeling of the meeting was not by any means that biological control is a method that is unlikely to prove of much value in the future, but that in the present state of our knowledge it is advisable to exercise the utmost circumspection in advocating such methods. Biological control differs from other control methods in several important particulars. It is a process which, once started, can neither be stopped nor controlled. Its action cannot be confined to any particular insect, to pests of any particular crop, or to any particular area. It can never be guaranteed that, in the field, the habits of the parasite will remain the same as they are found to be in the country of origin, or under experimental conditions. Change in habit with changed environment is of common occurrence in the insect world. It is hence very desirable that an elaborate and detailed study of the behaviour of each insect, in all stages, under every conceivable combination of circumstances, should precede its introduction into a new environment. At the moment the tendency is for any and every insect that it is thought might be useful to be introduced and tried, and there was a general feeling that this

policy is unwise and may lead to unpleasant complications in the future. At the same time, unless parasite work can be carried on at the same time by workers in different countries, whose observations can be correlated and whose work so arranged that the observations of each shall dovetail into those of the others, it is difficult to see how the comprehensive information desirable can be obtained.

A commencement, however, has been made with the establishment of parasite breeding stations in various parts of the Empire, which will not only serve as centres at which the work can be carried on, but also as centres for the distribution of parasites. Under the auspices of the Imperial Institute (then the Imperial Bureau) of Entomology, and with the help of the Empire Marketing Board, a laboratory for the purpose was established at Farnham Royal in Buckinghamshire in 1927. A large parasite laboratory in Saskatchewan is the latest addition to the activities of the entomological service in Canada. Parasite laboratories are also already in existence in Australia and New Zealand. As these centres develop, and others are opened in different parts of the Empire, it should become possible for workers on any insect to obtain information as to the presence in other countries of parasites likely to be of value to them, together with details of their habits, alternative hosts, environmental toleration, and so on. Up to the present it has been necessary, in all cases of this kind, to engage specialists in the various groups of parasites and despatch them to various parts of the world to search for likely parasites, make such observations as were possible, and endeavour to transport the living insects to their own country for further study. A further advantage in the establishment of these parasite breeding stations will be that they will afford training centres, where men can be adequately trained in this highly specialised branch of the profession.

This brings us to another particular feature of biological control which must be borne in mind, and that is, that this method can only be successfully carried on under the supervision of a sufficiently trained and adequate technical staff. It is not

a method in which the practical agriculturist can be instructed what to do, and, thus instructed, be enabled to carry it out successfully. The appointment and training of such a staff, and the establishment of well-equipped breeding stations at suitable centres, must of necessity precede the introduction of the control measure. In the early stages of the development of this method of control considerable apparent success was obtained in certain areas by the use of lady-bird beetles for controlling scales and aphides, and many, particularly among the uninstructed in entomological matters, formed the opinion that all that is necessary is to find a parasite of the pest, introduce it, and let it loose, when eradication of the pest will follow. Subsequent experience has shown that this is far from being the case, but the misconception, attractive of itself to the popular mind, and fostered from time to time by over-enthusiastic notices in the popular press, still persists in many quarters. Of large numbers of parasites tried, the number which have been successfully established is small, while not all those have had the desired effect, and instances cited during the discussion emphasized the complexity of the problem.

The control of weeds by insects was the next problem to be brought up for discussion. Dr. Miller, of the Cawthron Institute, New Zealand, opened with a statement of the general aspect of the problem, and Dr. Nicholson then followed with an interesting account of the work that has been done in Australia in controlling prickly pear by the introduction of insects. A caterpillar has been introduced which mines in the tissues of prickly pear, as a result of which fungi and other organisms gain access, and the prickly pear is killed down to the root in one year. Subsequent attempts to come away again are aborted by the insect, and eventually the weed is killed out. One hundred square miles had been cleared of prickly pear by the introduction of this insect to date. The insects are reared in special laboratories in the various districts, and eggs distributed enclosed in paper quills. The fieldmen in the various areas tie these quills on to the plants, and the caterpillars emerge and do

the rest. Thirty to forty different species of insect were introduced and tried, some of which were partially successful, before this particular pest was found. So far the caterpillar had not turned its attention to any other plant, but it had been found that an indigenous parasitic insect was turning its attention to the caterpillar, the percentage of parasitisation being now up to 3 to 4 per cent. Whether the insect or the parasite will win remains to be seen, but as it is not an egg-parasite distribution of the eggs continues to be a safe measure of introduction. Dr. Nicholson exhibited lantern slides showing destruction of the prickly pear by the caterpillar, and his contribution to the discussion was both interesting and convincing. It was, however, it must be noted, purely and simply an account of one case in which success has been attained, and it was the only such case quoted. As in the case of control of insects by parasitic insects, control of weeds in a similar manner depends for success on the occurrence of a certain combination of favourable circumstances which in experience is found to happen in only a minority of instances. Weed control by the introduction of insects is not possible under all conditions. A primary essential is that the weed concerned shall be entirely unrelated to any useful plant grown in the country, as unless this be the case the introduction of insects to destroy it results in the introduction of potential pests of other plants. Another essential is that the insect introduced shall be one that is entirely specific to that particular weed, and not likely, under the changed conditions of its new environment, to turn its attention to other plants. Add to these two limiting factors the fact that areas in which weeds can flourish to such an extent as to require special methods of control, beyond those exerted by proper cultivation, are generally such that the return per acre is so low as not to justify even a moderate expenditure, and it will readily be seen that weed control by insects has a restricted application. Delegates gave various accounts of work that had been done in this connection, mostly of a preliminary nature, and much of which showed the necessity for a study of the factors affecting the choice of a food plant by an insect.

Planters in Cachar and Sylhet will be interested to learn that the Imperial Entomologist brought up the question of water hyacinth, in the hope that some delegate would be able to give information on pests of this weed, but no information was, unfortunately, forthcoming.

The last subject to be discussed was the control of orchard pests, and this discussion was opened by Dr. Hall, entomologist to the British South Africa Company in Southern Rhodesia. Dr. Hall discussed the matter from the point of view of the practical man, and laid stress, from the onset, on the point that the cost of the operation is of paramount importance to the agriculturist, and must be gone into very carefully before making recommendations. He thought that this important point was often overlooked by officers in Government employ, an expression of opinion which provoked considerable discussion later. The possible methods of controlling orchard pests are tent fumigation, spraying, dusting, biological control, and cultural control. As the last two aspects of the problem had been dealt with separately at previous meetings, discussion centred mainly round the first three.

Tent fumigation is generally used for dealing with scale insects, and consists in erecting a tent over the tree to prevent dissipation of the fumigant, and liberating some such gas as hydrocyanic acid beneath the tent. A great drawback to this method is the expense, and in practice it is found that as a few scales are always left the operation has to be repeated next year. An interesting remark made by Dr. Hall was that freedom from scale, where it was found to occur, generally accompanied weakness of the plant and poor crop.

Success in spraying under orchard conditions, Dr. Hall found, was dependent on the provision of adequate and sufficient equipment and an adequate staff to carry out the work. In dealing with citrus orchards in Southern Rhodesia it was necessary to have enough machines to spray the orchards once every ten days. He had not found dusting so efficient as spraying, and

though most estates had machines, dusting was only used to supplement spraying, as with dusting the ground could be covered more quickly. He also found it more expensive than spraying.

Another factor affecting the success of spraying, pointed out by several delegates, is the time of application. Half the battle, in this work, is to be prepared, and to apply the spray at the right time. Most growers wait until the attack is sufficiently serious to alarm them before reporting it or taking any steps. Apart from this, many delegates referred to the fact that unequal flowering of the trees often makes it very difficult to spray all the trees at the right time, and that cultural methods designed to control the time of flowering of the trees are generally necessary as well if benefit is to be derived from spraying.

The writer asked Dr. Hall for information as to sprays that he had found to be effective. He said that he had tried everything he could lay hands on, but had not yet found what he wanted. As a general spray against Citrus aphis and thrips, he used lime-sulphur, with, if possible, nicotine added, but the latter made the spray so expensive that most orchards could not afford it. An additional advantage of lime-sulphur was its fungicidal properties. No other delegate suggested anything better so that the result of the discussion, so far as it concerns tea, was to emphasize the fact that the spray fluids recommended for use in tea cannot as yet be improved upon.

THE TULSIPARA EXPERIMENTAL BLOCK.

BY

H. R. COOPER, AND C. J. HARRISON.

The selection of a suitable block.

Early in 1930 the question of carrying out field experiments in a district in which the tea was liable to tea mosquito attack, was raised. Of several offers which were made, one by Messrs. Duncan Bros., of 20 acreas of tea at Tulsipara Tea Estate in the Dalgaon district of the Dooars was accepted. The reasons influencing the selection of this area were :—

1. The soil is a sand, normally acid, very rich in available phosphoric acid, and in every respect a good average sample of a soil very liable to mosquito blight in the Dooars.

2. Mosquito blight has always been very bad on this area and the surrounding tea also is always badly attacked. We are therefore unlikely to suffer the disappointment (experienced on many small areas on which experiment has been tried) of seeing the blight, as a serious pest, disappear from all plots (treated and untreated alike), as soon as the regular plucking and cultivation given to experimental plots, keeps bushes flushing regularly.

3. The area is on an even slight slope, so that all small plots on it have practically the same aspect.

4. The tea is very fairly even compared to the tea on most gardens and vacancies are few.

5. The tea is triangular-planted in a perfect parallelogram bounded by roads, so that it is easy to divide into small plots of equal size, such as are required for field experiments.

Type of soil.

The soil is of the grey sandy loam type and the following is an analysis of a typical Tulsi-para soil.

Coarse sand	...	20.3%
Fine sand	...	40.1%
Silt	...	27.8%
Fine silt	...	4.8%
Clay	...	3.0%
Loss on ignition (organic matter)	...	3.0%
Soluble in dilute acid	...	0.58%
Organic matter (Grandeau)	...	0.77%
Total nitrogen	...	0.084%
Available potash	...	0.007%
Total potash	...	0.720%
Available phosphoric acid	...	0.051%
Total phosphoric acid	...	0.187%

The soil is a very sandy one about normal in nitrogen, low in available potash and very high in available phosphoric acid.

Many patches of soil in this district are very high in lime and correspondingly low in acidity, so that before selecting this area, tests were made to see whether the soil was sufficiently acid to be a representative normal sample. pH determinations were made on samples taken from one end to the other. The results were :—

	1.	2.	3.	4.	5.	6.	7.
pH =	5.2	5.5	5.5	5.7	5.4	5.5	5.4

These figures indicate that the soil is quite sufficiently acid to grow good tea. Further complete analysis of the soil from the check plots will be done in 1931.

Description of the tea and its treatment.

The tea is a small dark leaved type from seed obtained from a neighbouring garden, Hantapara, and was put out with two-year old plants in 1921. The

following table gives the treatment of the tea from the time of first plucking.

Year.	Pruning.	Plucking.	Manuring and green crops.	Crop.
1924	14″ from ground and light centring.	32″ from ground.	Cowpea and daincha ...	64 lbs. per acre.
1925	Unpruned.	36″	Cowpea ... ... Cattle manure on stony ridges.	3·89 mds. per acre.
1926	Skiffed.	36″	Sterilised animal meal 200 lbs./ acre ... ... Cattle manure on ridges ...	2·96 mds. per acre.
1927	Light pruned 20″	32″	Nervox 3 cwts. per acre in trenches with prunings ... Cattle manure on ridges ...	5·0 mds. per acre.
1928	Unpruned.	...	Daincha on stony ridges ...	8·4 mds. per acre.
1929	Light pruned to 21″	32″	Sterilised animal meal 2 cwts. per acre ... ... Boga medeloa	6·1 mds. per acre.
1930	Light pruned to 22″	30″	Medeloa hoed in ...	6·3 mds. per acre.

The tea has received little manure except for a small quantity of sterilised animal meal; cattle manure and green crops on the stony ridges, and cuttings from boga medeloa. No manure was put on in 1930.

Plan of experiment.

To start with the area was divided in one direction into 11 equal strips labelled A to K, each 20 bushes wide, and in the opposite direction into 22 strips each 10 bushes wide and numbered 1 to 22. This gave 242 plots each containing 200 bushes. Each plot was marked with an iron post at each corner and labelled according to the horizontal and vertical strip into which it fell. For the 1930 season the leaf from each plot was weighed up separately so that from the yield for the season for each plot, an idea could be obtained of the relative yielding capacity of the plots before treatment. This information is essential before devising a lay out of plots for experiment. Yields have varied considerably,

those in the top right, and bottom left hand corners being generally lower than those in the other corners. This due to a stony ridge, which runs diagonally, on which are situated the poorer plots. It has been possible however to divide the area up into five main sections,—four large and one small, on which experiments on different subjects are to be carried out. In the plan of the experimental area the thick red lines mark off the separate sections, each section being concerned with experiments on a particular subject. The thick black lines mark off the sets of blocks within the sections. Each block contains one plot under each of the various treatments tried in that section. Each series, or treatment, is indicated by the black number inside the area representing a small plot. The red figures are the crop yields in lbs. of leaf per plot for 1930. Thus the twenty-first plot numbered from the left in the K line, (or plot 21K), which gave 169 lbs. of leaf in 1930, is under treatment 1 of the pruning trials. Reference to the detailed description of the pruning trial given below, will show that plot 21 K is cleaned pruned in December annually. Other plots getting similar treatment are 19K, 13K, 5K, 2I, 9I and 15I. Detailed descriptions of these experiments are given below.

Information is sought on four subjects.

Pruning Experiments. The general method of pruning as practised particularly in the Surma Valley, the Dooars and the Terai (where mosquito is prevalent) consists in a top prune leaving one or two fingers of new wood, generally without any attempt at removing weak and dead wood and *banjhi* shoots. This is as much as can be done at the price per acre generally allowed for pruning work, but when done continually for some years, leaves diseased bushes full of weak and unproductive wood. The cost of top pruning with good cleaning out is naturally considerably greater than if no cleaning out has been done previously.

Presumably general experience in these districts indicates that the extra cost of cleaning out, except at comparatively rare intervals, is not justified.

Many areas of Upper Assam used to be very seriously attacked by mosquito. It has now practically disappeared as a serious pest. The most marked difference which can be observed between planting methods in Upper Assam and in districts where mosquito attack is still very serious, lies in the pruning, and particularly in the practice of annual cleaning out.

The times of pruning and the intervals between prunings may also prove to be of importance.

The effects of the following treatments will therefore be compared at Tulsipara.

Series.	TREATMENT.
1	Moderate clean prune in December annually.
2	Cut across ,, ,, ,,
3	Drastic clean prune ,, ,, ,, (in 1931 stick pruned).
4	As series 1, in alternate years.
5	,, ,, 2, ,, ,,
6	,, ,, 3, ,, ,,
7	Moderate clean prune at 18 months interval December and June.
8	Moderate clean prune in March annually.
9	As series 8 in alternate years.

The drastic clean prune involved taking out an enormous amount of wood from the bushes this year, but in future years there should be very much less wood to remove now that the bushes have been thoroughly cleaned up.

Manuring Experiments. The following treatments are being tried :—

Series.	lbs. per acre nitrogen.	lbs. per acre phosphoric acid.	lbs. per acre potash.
1.	*nil*	*nil*	*nil*
2.	40	*nil*	*nil*
3.	40	40	*nil*
4.	40	*nil*	40
5.	40	40	40
6.	40	*nil*	80
7.	80	*nil*	*nil*
8.	80	*nil*	80
9.	80	*nil*	160

The manures to be applied are :—

200 lbs. per acre sulphate of ammonia to supply 40 lbs. per acre nitrogen.
222 ,, ,, ,, superphosphate ,, ,, 40 ,, ,, ,, phosphate.
60 ,, ,, ,, sulphate of potash ,, ,, 40 ,, ,, ,, potash.

The number of plots available limits the number of trials which can be made. The effect of time of application and of potash alone might usefully have been tested, but this would have required many more plots. The trials have been limited chiefly to testing the effects of two different quantities of nitrogen each with varying quantities of potash. The above trials include the following groups :—

	Nitrogen.	Phosphoric acid.	Potash.
Group 1	40	0	0
	40	0	40
	40	0	80
Group 2	80	0	0
	80	0	80
	80	0	160

Both the above will show the effect of increasing supplies of potash accompanied by the same quantity of nitrogen.

Phosphoric acid on this soil is likely to prove unnecessary and may prove even harmful. Its effect will be tested by the following treatments.

Group 3	40	0	0
	40	40	0
Group 4	40	0	40
	40	40	40

The effect of increasing nitrogen will be seen from the following groups :—

Group 5	0	0	0
	40	0	0
	80	0	0
Group 6	40	0	80
	80	0	80

And results may be checked also by comparing the effect of doubling an application in the following pairs :—

	Nitrogen.	Phosphoric acid.	Potash.
Group 7	0	0	0
	40	0	40
	80	0	80
Group 8	0	0	0
	40	0	80
	80	0	160

The nine series of plots, then, afford 8 interesting comparisions; and although they will not afford all the information desired, what is obtained will be very useful.

It is hoped that the doses of potash may eventually have some effect in counteracting the effect of the high available phosphate in the soil in increasing liability to mosquito attack.

On a small block, the relative efficiency of the slower acting cattle manure, which supplies also organic matter, is to be compared with an equivalent quantity of quick acting artificial manure.

Series 1. Cattle manure at 5 tons per acre.
,, 2. Equivalent quantities of artificial manures.
Sulphate of ammonia about 200 lbs. per acre.
Superphosphate ,, 200 ,, ,, ,,
Sulphate of potash ,, 80 ,, ,, ,,

The actual quantities of artificials will be worked out after analysis of the cattle manure, so as to supply the same quantities of nitrogen, phosphate and potash as occur in 5 tons of cattle manure.

Plucking Experiments. It has been shown at Borbhetta that the closer a bush is plucked the more leaf is obtained, at least until such time as the bush deteriorates from over-plucking. This also is in accord with general experience in Assam. In

mosquito districts, however, the opinion is very widely held that it is essential to pluck more sparingly, and particularly not to pluck to the *janam* too soon. On the other hand it has often appeared that regular plucking at close intervals keeps a bush flushing in spite of the presence of mosquito.

Apart from any hope of cure from difference in plucking, it is essential to determine the effect of differences in plucking, on the crop obtainable in the presence of mosquito blight. It has been urged, with much reason, that results obtained in the absence of mosquito blight cannot apply where the question is complicated by attack by mosquito.

The following styles of plucking will be tried at Tulsipara. Series. 1. Plucked to 6″ and to the *janam* at 7-day intervals.

,,	2.	,, 8″ ,, ,, ,, ,,
,,	3.	,, 6″ then one big leaf and then to the *janam* at 7-day intervals.
,,	4.	,, 8″ then one big leaf and then to the *janam* at 7-day intervals.
,,	5.	,, 6″ then one big leaf left till 15th. August then to the *janam* at 7-day intervals.
,,	6.	,, 4″ then one big leaf left at every round, at 7-day intervals.
,,	7.	,, as series 1, but at 10-day intervals.
,,	8.	,, as series 7, but not broken back.
,,	9.	,, as series 1, but at 14 days intervals with no breaking back.

In all series except 8 and 9, breaking back of long shoots will be done throughout the season when necessary.

Cultivation Experiments. On the subject of the effect of cultivation on attack by mosquito blight, many widely varying opinions have been expressed. On this subject also accurate information is very desirable.

Styles of cultivation varying from clean hoeing to practically none but such as is necessary to get the bushes plucked,

are therefore to be tried, both with and without a deep hoe in the cold weather.

The Cultivation Block consists of 40 plots, 20 of which will, in the cold weather after pruning, get a deep hoe, while 20 will get only a light hoe in place of the deep hoe.

Four forms of cultivation will be tried both in the deep-hoed plots, and on those not deep hoed.

These are :—

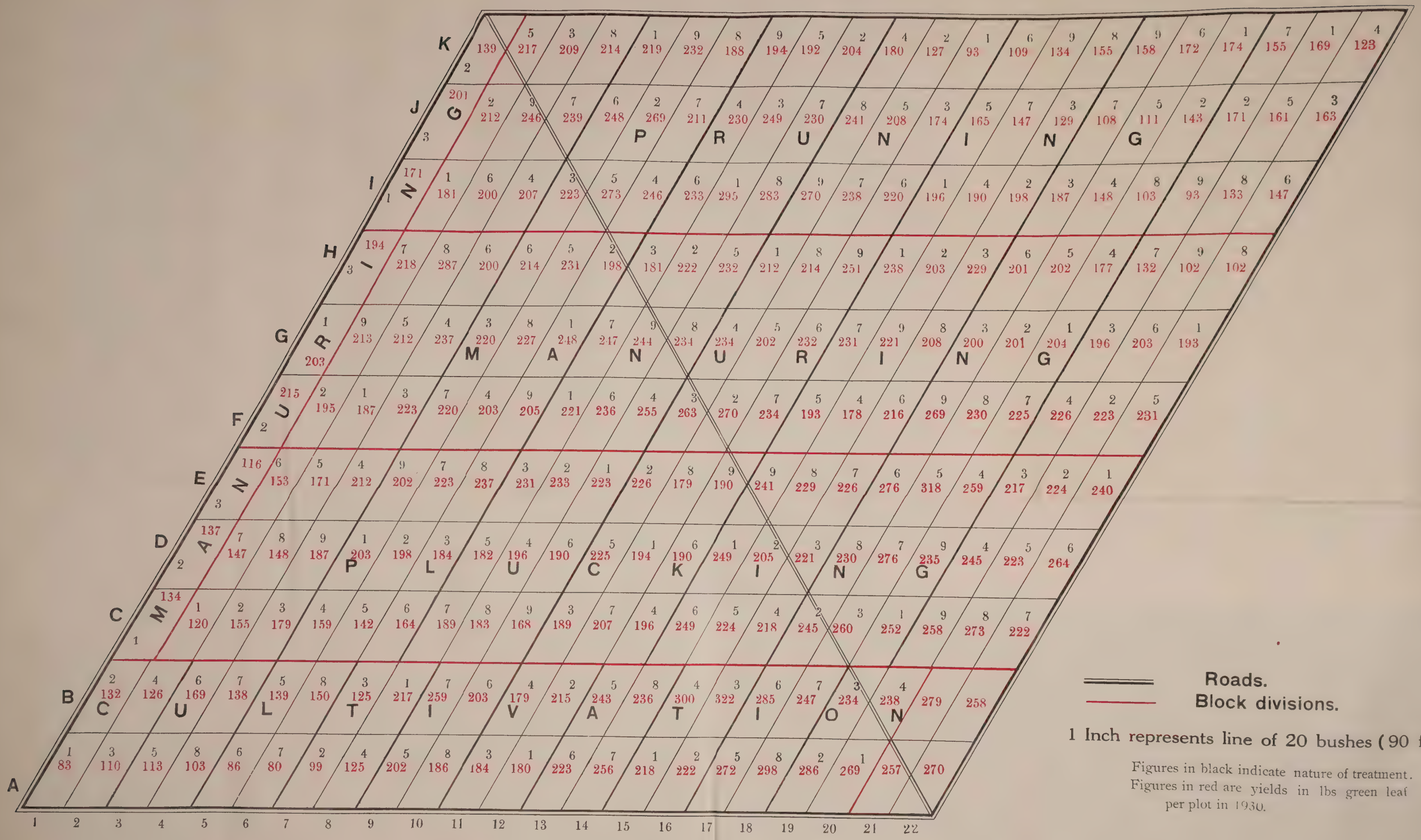
Deep hoed.	Not deep hoed.	Other treatment.
Series 1	Series 5	8 light hoes, one each month except January, February, November, December.
,, 2	,, 6	4 light hoes, in April, June, August, and October.
,, 3	,, 7	8 rounds of cheeling, one each month except January, February, November, and December.
,, 4	,, 8	8 round sickling, one each month except January, February, November, and December.

"Cheeling" will consist in scraping off the weeds (with a hoe) together with as little of the soil as possible, leaving the weeds and loose soil piled between alternate rows of bushes. In the next round the position of the pile of scrapings will be changed to the next row, so that the whole surface of the soil is scraped, and weeds suppressed, with practically no disturbance of the soil.

All the trials made are repeated on several plots. For example the trials on manuring, plucking, and pruning are each made on 63 plots divided into 7 blocks of 9 plots. Each block includes one plot under each of the nine treatments. Each experiment is therefore repeated seven times.

Every team (or series) of seven plots is selected so that the aggregate yield in 1930, was practically the same from each team.

PLAN OF TULSIPARA EXPERIMENTAL PLOTS



The plots assigned to manuring experiments may be quoted as an example.

The figure followed by a letter indicates the position of the plot. The accompanying plan will make this clear. The figure following gives the number of lbs. green leaf plucked from the plot in 1930.

Yields 1930.

Block number.	Series.																	
	1		2		3		4		5		6		7		8		9	
1	3F	187	2F	195	4F	223	4G	237	3G	212	4H	200	2H	218	3H	287	2G	213
2	7G	248	7H	198	5G	220	5F	203	6H	231	5H	214	5F	220	6G	227	7F	205
3	8F	221	9H	222	8H	181	10F	255	10H	232	9F	236	8G	247	13G	234	9G	244
4	11H	212	12F	270	11F	263	11G	234	12G	202	13G	232	13F	234	12H	214	13H	251
5	14H	238	15H	203	16H	229	15F	178	14F	193	16F	216	14G	231	16G	208	15G	221
6	19G	204	18G	201	17G	200	19H	177	18H	202	17H	201	19F	225	18F	230	17F	269
7	22G	193	21F	223	20G	196	20F	226	22F	231	21G	203	20H	132	22H	102	21H	102
Aggregate	1503		1512		1512		1510		1503		1502		1507		1502		1505	

It will be seen that the aggregate yields in 1930 of the series (or teams) of plots chosen, varied between 1502 and 1512 lbs.—a difference of less than 1%.

It is therefore probable that if treatment continued the same for all series, the aggregate yields in 1931 would continue to be at least very similar. If marked differences in aggregate yield appear after different treatment, these differences may be ascribed, quite fairly, to the effects of the treatment given.

METEOROLOGICAL OBSERVATIONS IN NORTH EAST INDIA, 1930.

BY

C. R. HARLER.

The 1930 season in Assam.

The 1930 tea season in North East India was an average one so far as crop was concerned, although direct comparison with previous years is difficult because of the complicating factor of crop restriction in the year under discussion. A true comparison over a series of years is also rendered difficult because the fineness of plucking varies with the market value of tea. At Borbhetta, however, on sections where plucking and treatment have been constant for some years, the 1930 crop was similar to that in 1928.

In Assam, many tea gardens in 1930 were down about 10% on the 1929 crop. This drop was mainly due to weather, and in a lesser degree to labour shortage at the height of the season and to finer plucking.

The table below shows the variation in the Brahmaputra Valley tea crop per acre since 1927, and also the variation shown by certain Borbhetta plots where the treatment has not varied for some years. The actual crop figures in the Brahmaputra Valley for 1930 are not yet available, the percentage shown below being taken from garden reports. The 1927 crop is taken as 100% and that of subsequent seasons calculated on this figure.

	Brahmaputra Valley.	*Borbhetta.*
Season 1927	... crop 100%	crop 100%
,, 1928	... ,, 109%	,, 103%
,, 1929	... ,, 112%	,, 110%
,, 1930	... ,, 101%	,, 102%

The progress of the 1930 season was as follows. The first two months of the year were normal, with average rain resulting

in a sufficiently moist soil. March was cooler than the average. April was cool and dull, although only 5.40 inches of rain fell compared with an average of 7.75 for this month. Red spider was severe at this period not on account of droughty conditions but because of dull wet weather. Ideal spring conditions appear to consist of dry warm periods in February and March which heat the soil to shallow depths, followed by rain and sun in April and May. The result is vigorous early growth and practical absence of red spider.

It may here be noted that for the sixth year in succession high winds during the early months of the year were absent. Prior to this and over a period of 5 years, *viz.*, 1920 to 1924, severe winds, causing much damage, occurred in the spring of each year.

The dull wet spell of April continued till May 8th., after which followed a period of high temperatures. Towards the end of May very big flushes occurred and these carried on into June, after which the crop tailed off badly.

The rush of crop in May and June consisted largely of quick growing long, wiry shoots, and of slow growing leaf from the delayed first flush. The thick, stocky shoot which usually makes up the second flush was not so much in evidence as in normal seasons, and the teas were below the usual standard. Over long spells in June, withering conditions were very poor, and this also helped to reduce second flush quality. An absence of green fly coincided with a frequent failure of the spring teas to show marked flavour.

July was abnormally dry, showing a low record precipitation for the past 12 years of 7.04 inches, against an average of 16.14 inches at Tocklai. The dry July was partly brought about by a depression in Central India which apparently deflected the monsoon drift away from Assam. The prevailing wind during most of this month was from the north-east, our dry quarter, and not till the last few days of the month was the south-west monsoon current re-established.

On the 3rd. of July a severe earthquake shock was recorded at about 3-30 *a.m.*, lasting for about 30 seconds. The epicentre of the disturbance was about Rungpur and Dhubri.

August was a record wet month, so far as Tocklai records go, with a rainfall of 23.41 inches against an average of 11.48 inches. During the dry July, the rice fields were not in a suitable condition for ploughing customary in this month. Accordingly when the rain came in August, more labour than usual left the gardens for rice cultivation. As a result the leaf got away on many areas and much crop was thereby lost, and quality lowered.

The cold weather grass, Kohua (*Saccharum spontaneum*), first bloomed in the Jorhat district on August 20th., which is about the average date. That the appearance of this grass is no indication of the nature of the close of the season is evidenced by the fact that the year under consideration shut up early.

September was a dry month with precipitation of 8.12 inches, about 3 inches below normal. The total rainfall to the end of September was 64.74 inches, about 12 inches behind the average.

October was also dry, with the wind blowing from the north-east most of the time, in keeping with the persistent weakness of the monsoon throughout the season. The advance of the cool weather was rapid and average temperatures in this month were maximum and minimum 83/68°F., against normal values of 87/70°F. These low temperatures made an early close certain.

The first cold weather mists appeared on the 24th. October.

November was cooler and wetter than the average. Record rainfall, 3.61 inches, for this month was registered and maximum temperatures were 78°F., against an average of 82°F.

The mean December temperature was rather cooler than normal, although the minimum never fell below 44°F., about

4°F., in excess of normal. The total rainfall for the year was 72.85 inches against an average of 82.57 and a total of 95.27 inches, in the previous year, 1929.

Variability of Rainfall.

The table below shows the monthly rainfall at Tocklai together with the average of the last 12 years, including 1930. For comparison the 1930 rainfall at Pabhojan in Doom Dooma, and at Sylee in the Dooars, is also shown.

Table showing rainfall.

	Average Tocklai.	Tocklai 1930.	Pabhojan 1930.	Sylee 1930.
	ins.	ins.	ins.	ins.
January	1·07	0·70	0·88	0·15
February	1·39	1·70	2·41	1·70
March	3·16	3·62	3·57	3·18
April	8·03	5·40	13·93	3·68
May	8·56	5·09	5·39	7·95
June	13·54	9·66	15·77	30·43
July	15·35	7·04	10·35	21·34
August	13·32	23·41	15·14	44·68
September	10·76	8·12	22·10	18·81
October	5·07	3·81	7·88	9·95
November	1·20	3·61	3·59	7·30
December	30·7	0·69	0·42	0·10
Total ...	81·84	72·85	101·43	144·79

The average total for Pabhojan is 99.30 inches and for Sylee 164.48 inches.

It will be noticed that whilst both Sylee and Tocklai recorded less than average rainfall the Pabhojan value was just above normal. From west to east in the tea districts of North

East India the variability of the rainfall decreases. Thus in the Dibrugarh district, at the head of the Assam Valley, the rainfall is more certain that it is in the centre of the Valley or in the Dooars. In addition the distribution improves from west to east and the cold weather drought is shorter and taxes the resources of the tea bush much less in Dibrugarh than in areas lower down the Valley.

The outstanding characteristic of the rainfall in the greater part of India is its variability, in which respect it is possible to maintain two broad generalisations,* *viz* :—

(*a*) The lower the average rainfall the greater the variability.

(*b*) Rainfall is distinctly less reliable when it is characteristically concentrated than when it is well distributed in time.

It is obvious that these two tendencies may interact the one against the other. For example, the rainfall in the Dooars is much higher than in Assam but it is more concentrated in the monsoon months. The result of these two factors, in this particular case, is a less reliable rainfall in the Dooars than in Assam. In the Assam Valley, however, there is a remarkably close correlation between maximum variability and minimum rainfall when the former is calculated by certain methods now to be described.

Variability in rainfall may be calculated in several ways. The method employed in the paper quoted below * is as follows. If for a 34-year period (for example), d_1, d_2, d_3 ..... d_{34} are the divergencies from normal arranged in descending order, irrespective of sign, V = variability, and N = normal rainfall,

$$\text{then } V = \frac{100\ (d_{16} + d_{17} + d_{18} + d_{19})}{4\ N}$$

To illustrate the use of this formula the variability of the rainfall at Tocklai may be calculated. The table below shows

* Williamson, A. V. and K. G. T. Clark. The Variability of the Annual Rainfall in India *Quarterly Journal, Roy. Met. Soc.*, London, 1931, (vol. 57, p. 43, Jan. 1931).

the annual Tocklai rainfall over the past 12 years, and the departures from normal.

Tocklai Annual Rainfall.

Year.	*Rainfall.*	*Departure from normal.*
	ins.	
1919	76	− 5
1920	68	−13
1921	82	+ 1
1922	74	− 7
1923	101	+20
1924	66	−15
1925	86	+ 5
1926	75	− 6
1927	93	+12
1928	83	+ 2
1929	95	+14
1930	73	− 8
	Average ... 81	

When the departures from normal are arranged in descending order of magnitude, it is seen that the four middle figures on the group are 12, 8, 7 and 6, making a total of 33. From the formula,

$$\text{then } V = \frac{100 \times 33}{4 \times 81} = 10{\cdot}2$$

The variability of rainfall at Tocklai is thus said to be 10%, taking the value to the nearest unit. The percentage is merely a comparative figure and has no reference to the total rainfall itself.

Using this method of calculation it is seen that the variation in rainfall in the Assam Valley is about 12%, except in that part which lies in the lee of the highest section of the Khasi Hills, where it rises to about 20%. The table below shows typical values taken through the Valley.

	Average Annual Rainfall.	*Variability.*
Goalpara (west end of Valley) ...	95 inches.	11%
Nowgong (centre)	70 „	19%
Dibrugarh (east end of Valley) ...	105 „	10%

The arbitary nature of this method of calculation is obvious, since the extreme departures from normal, *i.e.*, the d_1, d_2, d_3... values, are discarded and the calculations made on more common, albeit smaller, departures.

Another method for calculating variability is that employed by Biel * which sums all the differences from normal and divides this by the number of years. Thus in dealing with a 34-year period, the percentage variability is given as follows.

$$V = \frac{(d_1 + d_2 \ldots\ldots + d_{33} + d_{34})}{34}$$

This method gives some consideration to extreme departures from normal. Using the method in connection with the rainfall in the Assam Valley, values similar to those previously shown, for Goalpara, Nowgong and Dibrugarh are obtained. Applying the method to the Tocklai rainfall, a variability of 9% is obtained against a value of 10% by the former method.

Whilst the percentage variability indicates how far the rainfall may be relied upon in any particular area it is at once apparent that this factor makes only a very slight and indirect contribution to the complicated problem of rainfall as a factor in crop production. Variability as defined above is not variability from optimum conditions for any particular crop. Thus 1920 was a standout year for tea growth in Assam, yet this year shows one of the greatest departures from normal rainfall. The 1924 season was standout for quality, yet this year showed the maximum departure from average so far as rainfall was concerned. Again it will be remarked that Nowgong, in spite of the high variability in precipitation, is far preferable to Goalpara as a tea district.

In the Dooars the variability, calculated by either of the above methods, is about 10%, yet the concentration of the rain in the monsoon period and the normal severity of the drought are two factors which make this area a much more difficult one for tea than Dibrugarh.

* Biel, E., *Geogr. Jahrber, Ost.*, Vienna, 1929 (14-5).

Although the methods of calculating variability already described may be of use in indicating the reliability of certain areas for certain crops, any method which does not give the fullest consideration of extreme conditions is of little use in connection with the suitability of a district for tea. Tea is a perennial crop and the bushes are usually rooted to about 3 feet deep. Tea is thus unable to withstand a drought as well as a grown tree, and one very dry season in every twenty, for instance, is sufficient to make an area wholly unsuited as a tea country.

One method of calculating variability in rainfall which is indicative of the suitability of an area for tea growth is the following, which deals only with absolute maxima and minima.

$$V=\left(\frac{\text{absolute max.} - \text{absolute min.}}{\text{average rainfall}}\right)\times 100$$

Applying this formula to Tocklai rainfall records the following is obtained.

$$V=\left(\frac{101-66}{82}\right)\times 100=43\%$$

The same method gives the variability at Sylee as 55%, in the Terai 62% and in parts of Behar 108%. These figures generally give a rough comparative measure of the suitability for tea of the areas under consideration.

Of recent years much has been heard of the suitability of various parts of Africa for tea cultivation. Although average conditions in many parts of East Africa are suitable for tea, the occasional season when the rainfall is very low would either kill out the tea or weaken it so much that it would take several years to recover.

Sunshine.

The 1930 monthly sunshine records for Tocklai, Pabhojan and Sylee are given below. The average at Tocklai for the past 13 years including 1930 is also given.

This year a sunshine recorder has been installed at Tilkah, in Cachar, and in future these records together with other observations will be available for this district.

In previous meteorological reports the effect of sunshine on the tea crop, on quality and on the incidence of certain pests and blights has been discussed. No further remarks on these aspects of the subject need now be made, but the observations of the year 1930 are put on record.

Table showing sunshine in hours.

	Tocklai average. 13 years.	Tocklai 1930.	Pabhojan 1930.	Sylee 1930.
January	167	162	155	155
February	169	188	178	204
March	187	169	124	177
April	158	160	127	185
May	151	190	232	249
June	129	105	106	136
July	134	138	...	161
August	143	142	129	91
September	128	129	156	197
October	158	148	132	164
November	168	139	130	225
December	164	148	152	241

The very sunny May should be noted. At Sylee the previous highest figure for this month in the last six years was 217 hours in 1927. The exceptionally dull August at Sylee also calls for comment, the average sunshine for this month in the last six years being 128 hours.

The weather chart for 1930.

The weather chart and crop curve for 1930 is shown opposite. It is constructed on the lines of previous charts used in these Reports.

The top curve shows the soil moisture which during February was below the optimum, as also at times in March. Thereafter it seldom fell below 15%, which may be reckoned about the minimum for Tocklai soil below which conditions are unfavourable.

The wind curve shows no points requiring special comment. Points of note in the temperature and rainfall have already been mentioned in the description of the season.

SEASON 1930.

Jan. 5 12 19 26 | Feb. 2 9 16 23 | Mar. 2 9 16 23 30 | Apl. 6 13 20 27 | May 4 11 18 25 | June 1 8 15 22 29 | July 6 13 20 27 | Aug. 3 10 17 24 31 | Sept. 7 14 21 28 | Oct. 5 12 19 26 | Nov. 2 9 16 23 30 | Dec. 7 14 21 28

Soil Moisture

20%

15%

10%

Soil Moisture

Daily Wind

100 Miles

50 „

Wind

Crop

400 lbs.

300 „

200 „

100 „

Crop

A—annually pruned and plucked to 8″ new wood

B- unpruned

B

A

1·00 inch

Vapour Pressure

0·90 „

0·80 „

0·70 „

0·60 „

0·50 „

0·40 „

0·30 „

Vapour Tension (Inches mercury)

Temperature 100° F.

Rainfall 10 ins.

Maximum Temperature

Minimum Temperature

Rainfall

8″ 6″ 4″ 2″ 0″

90° 80° 70° 60° 50° 40°

Observations made at Tocklai Experimental Station.

The crop curve represents the green leaf from the Tocklai Clearance, an area of about 2½ acres. Half the area is pruned annually and half biennially. The plucking is carried out strictly at 7-day intervals and is to the *janum* on an 8-inch growth on the pruned area. The unpruned bushes are given no growth, but are plucked down to the plucking level left at the end of the previous season.

The first point of interest is the comparative failure of the unpruned area, an experience which has been frequent since 1922. The first rush of leaf was in May and June, after which a depression, more serious than usual occurred. The depression after the second flush is partly due to the fact that growth from the lower axils has not reached the plucking table and also partly to the fact that the bush goes *banjhi* or dormant after the spring impulse. Whether this resting phase can be overcome by manuring or other treatment is a subject now under study. It is of interest to note here that bushes pruned any time between December 1st. and April 1st. all show a dormant period at the end of June.

The crop on the Tocklai Clearance fell off after the middle of October, almost a month later than in 1929, in spite of the fact that the 1929 back-end was more favourable climatically than that of 1930. The addition of a double application of manure in 1930 (*viz.* 80 lbs. nitrogen per acre against 40 lbs. in 1929) accounts for the good finish to the season on the Tocklai Clearance.